WPS 2890

POLICY RESEARCH WORKING PAPER 2890

Sector Organization, Governance, and the Inefficiency of African Water Utilities

Antonio Estache
Eugene Kouassi

The World Bank
World Bank Institute
Governance, Regulation, and Finance Division
September 2002

Abstract

Estache and Kouassi analyze the determinants of the efficiency levels reached by 21 African water utilities. They assess efficiency through the estimation of a production frontier for the sector in Africa. The efficiency estimates confirm much of the common perceptions from partial productivity indicators. They point to a great heterogeneity in the African water utilities' performances, the predominance of constant returns to scale, and the great rate of technological progress. And the authors show that the institutional capacity of the country, as well as its governance quality, are significant driving factors in the performance of each firm.

This paper—a product of the Governance, Regulation, and Finance Division, World Bank Institute—is part of a larger effort in the institute to promote the understanding of regulatory issues. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Gabriela Chenet-Smith, room J3-147, telephone 202-473-6370, fax 202-676-9874, email address gchenet@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. Antonio Estache may be contacted at aestache@worldbank.org. September 2002. (21 pages)

SECTOR ORGANIZATION, GOVERNANCE, AND THE INEFFICIENCY OF AFRICAN WATER UTILITIES[1]

Antonio Estache*

***The World Bank Institute*, and**

ECARES, Universite Libre de Bruxelles

Eugene Kouassi

***Universite de Codody*, and**

***Resource Economics* – West Virginia University**

Keywords: Water utilities, unbalanced panel data, efficiency analysis, stochastic frontier models.

JEL Classification: C22, E23, E27

[1] We are grateful to I. Alikhani, A. Locussol, S. Perelman, L. Trujillo and all the participants to various seminars on regulation in West Africa for helpful discussions and suggestions.

* Direct correspondence to: Antonio Estache, the World Bank Institute, WBI, 1818 H St NW, Washington, DC 20433., USA. Tel. (202) 458-1442 Fax. (202) 676-9874 Email: Aestache@worldbank.org.

1. INTRODUCTION

Africa faces increasingly critical resource constraints in its effort to extend water services of acceptable quality to the vast majority of its people. (e.g., see Pouliquen, 2000; Sandelin, 1994; Snell, 1998; World Bank, 1999). The inefficiency of water utilities is often identified as one of the major factors. in explaining the slow progress and the many setbacks in improving access to water and water distribution (e.g., see Schuebeler, 1995; World Bank, 1999). Yet, there is a surprising dearth of literature attempting to measure the efficiency of operators in a way that would allow economic regulators to introduce explicitly performance incentives in the regulation of the operators in African countries. Perhaps because the partial productivity indicators, such as water losses or number of employees per connection, have generally been so poor that radical operational reforms were easy to propose, much of the attention of policymakers, donors and researchers seems to have focused on the institutional and financing aspects of water sector reforms. The need to mobilize additional resources for water through fees and other modalities of financing and the potential for an increased public-private partnership in the sector were particularly emphasized (e.g., World Bank 1999; UNDP-World Bank Water and Sanitation Program –West and Central Africa Office, 1998 and Snell, 1998)

The main purpose of this paper is to show that it is worth assessing more carefully the potential efficiency improvements that should result from the much emphasized reforms. This would allow quantitative assessments of the potential improvements in the overall use of inputs and a more analytical discussion of the optimal scale of operation. Both potential sources of efficiency gains could be set as targets for the restructured sectors and go a long way in cutting the financing requirements. This, in turn, implies that the need for tariff increases may not be as high as sometimes argued for some of the markets. Moreover, it implies that there is scope for regulatory supervision which ensures that the efficiency gains are not simply turned into pure rent for the new operators but are eventually shared with the consumers.

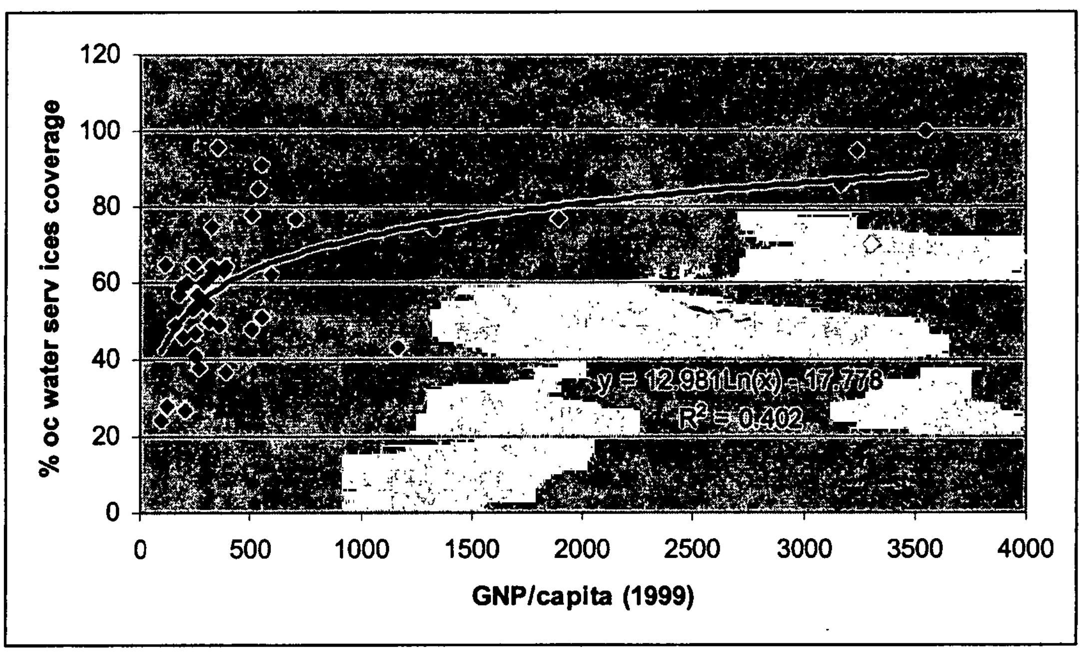
We assess the potential for efficiency improvements and the importance of the scale of operation by estimating a production frontier for the region. For lack of better data, we estimate this production function from an unbalanced panel of data for a sample of 21 African water utilities covering the 1995-1997 period. To contribute to the design of reforms, the paper also quantifies the joint effect of various institutional sources of inefficiencies and in particular assesses the costs of the interactions between inefficiency and major institutional problems, in particular governance problems hurting many African countries.

The paper is organized as follows. Section 2 presents a brief overview on the African water utility sector. Section 3 discusses the analytical and conceptual framework and introduces the panel data method for unbalanced data analysis. Sector 4 explains the data and empirical model selection procedure. Section 5 presents the empirical results; Section 6 discusses the results. Section 7 concludes with some policy implications.

2. SOME STYLIZED FACTS ON AFRICA'S WATER SECTOR

Currently, only 64% of Africa's urban population has access to safe water supply and 55% have access to sanitation. Of these, 14% have house connections and fewer have access to sanitation. The correlation of water coverage levels with income levels is clear as seen in Figure 1 but also more complex than many would expect since income levels explain only 40% of the differences in water coverage. This in turn suggests that there is more to improving access than waiting for growth to accelerate.

Figure 1: Access to Water and Income Level



One of the most obvious additional explanation for the differences in water coverage is the institutional arrangements adopted for the sector. Table 1 gives a snapshot of the organization of the sector in Africa during the period covered by this analysis. The data is collected from a survey of twenty one Africa water utilities. From a statistical viewpoint, it yields an unbalanced panel of twenty one utilities observed over the period 1995-1997 is representative of the total of one hundred and fifty water utilities in the region. The salient feature are that: (i) most utilities are in the public domain (85,71%); (ii) most of them are also water suppliers (77%); (iii) private sector participation in these utilities was very limited during the period analyzed (9.52%).

Table 1: African Water Utility Firms 1995-1997

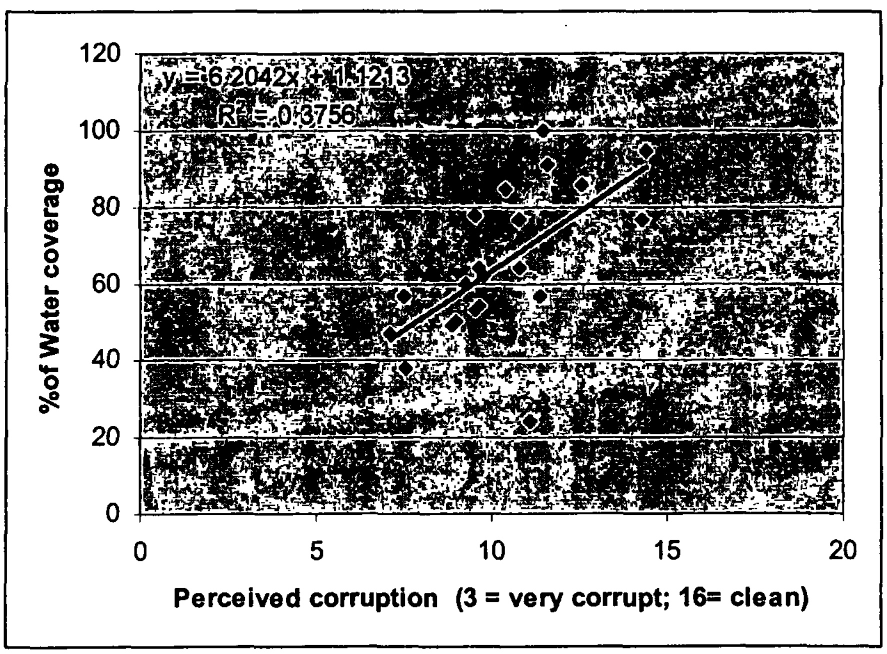
Country	Water Utility	Type of Utility	Area of Jurisdiction	Score of Activity	Private Sector Participation
Benin	SBEE	Public	Country	Water Supply	No
Burkina Faso	ONEA	Public	Country	Water Supply and Sewerage	No
Côte d'Ivoire	SODECI	Private	Country	Water Distribution	Leasing
Ethiopia	AA WSA	Public	Municipal	Water Supply	No
Ghana	GWSC	Public	Country	Water Supply	No
Mauritius	CWA	Public	Country	Water Supply	No
Morocco	ONEP	Public	Country	Water Supply	No
Morocco	RED	Public	Country	Water Supply	No
Namibia	WM	Public	Province	Water Supply and Sewerage	No
Níger	SNE	Public	Country	Water Supply	No
Nigeria	KdSWB	Public	Region	Water Supply	No
Nigeria	KtSWB	Public	Region	Water Supply	No
Nigeria	BoSWB	Public	Region	Water Supply	No
Nigeria	EdSWB	Public	Region	Water Supply	No
Senegal	SDE	Private	Country	Water Supply	Affermage
South Africa	UMGENI	Both Public and Private	Region	Water Supply and Sewerage	No
South Africa	RAND-W	Public	Region	Water Production	No
Togo	RNET	Public	Country	Water Supply	No
Tunisia	SONEDE	EPIC[2]	Country	Water Supply	No
Uganda	NWSC	**Public**	Country	Water Supply	No
Zambia	LMSC	Public	Province	Water Supply	No

Notes: a Public enterprise but with a privatized management.

What the table does not tell (partially because there is little specific data on this topic), is that the organization of the sector is shifting towards a community-driven development approach, ignoring the basic traditional assumption in the sector that economies of scale justify large utilities in order to reduce costs by making the most of economies of scale. This preference for smaller scale operations is clear in rural and peri-urban areas but it is also increasingly important in urban areas which continue to be under the control of more traditional water utilities. Indeed, even for these utilities, the need for constant interfaces with the users to ensure that supply meets the demand and willingness to pay leads to actual payments is now recognized as a necessary, although not a sufficient, condition for success.

The fact that utilities follow the demand orientation path adopted for rural and peri-urban approaches also reflect a desire to increase accountability with the hope that it will indeed improve and accelerate access to water services. This would imply that lower corruption or governance problems levels are expected to be associated with better coverage levels. Figure 2 provides a naïve confirmation of this intuition (with the notable exception of Ethiopia where geological conditions offset the benefit of a good governance score).

Figure 2 Correlation between Water Coverage and Governance Problemsn



This quick, and somewhat naïve, overview of the sector shows that the frustrated demand is likely to be great as revealed by the low coverage rates but also that the organizational structure of the sector and governance quality are likely to be important factors to account for. A more subtle third message is that it may be useful to have a more quantitative view of the supply side of this market to ensure that cost are minimized. Finally, it is also important to check the extent to which the institutional arrangements contribute to the reduction of these costs and hence to the better use of the resources available to expand and accelerate the investments needed to meet the frustrated demand.

3. ANALYTICAL AND CONCEPTUAL FRAMEWORK

In spite of the diversity of experiences with water sector provision in Africa, the overview presented in section 2 reveals the need to tackle four main policy issues. The authorities responsible for the water sector need to be able to: (i) compare as rigorously as possible the firms they are responsible for with similar firms in the region as, implying that an efficiency ranking of firms would be useful, (ii) assess fully potential efficiency gains for individual firms from better joint uses of all inputs, (iii) assess the efficiency costs of ignoring potential scale economies by focusing on smaller scale operations and (iv) assess the efficiency effects of governance problems.

While partial productivity indicators generally prove to be useful instruments to get a quick overview of the performance of any enterprise, they can often be misleading when comparing various firms. Not all partial indicators necessarily yield the same ranking and this is why we need to have a joint assessment of the effects of the key inputs if robust ranking are expected. Second, when setting targets for operational improvements and in particular cost reductions, once more, we need to account for the joint effect of all inputs rather than for the effects specific inputs and to come up with a single sector or firm specific figure which will serve as a target. Third, in view of the institutional changes which seem to spreading throughout the region and resulted in the decision to go for smaller scale operations, we also need to have an instrument that allows a fair assessment of the opportunity cost in terms in terms of economies of scale to be tapped. Finally, the limits of what can be done when corruption interferes with the process of reform must be recognized and assessed as well if targets are to reachable. The focus on technical efficiency as defined by economists allows us to address all of these issues.

3.1 Technical Efficiency: Concept and Measurement

The measurement of efficiency in the water sector is complicated by the nature of the production process (e.g, see Sengupta and Monsour , 1986; Eglal et al., 1996; Hunt and Lynk, 1995; Bishop and Thompsom, 1992; and Ashton, 2000). Complications arise from the fact that water production is a function of many variables, many of which are exogenous to the water sector – for example household income, chemical products prices, and intra-household decisions etc.

Farell (1957), drawing upon the work of Debreu (1951) and Koopmans (1951), introduced a measure of productive efficiency that avoids the problems associated with traditional average productivity measures (ratios). He proposed that efficiency relative to a best-performance frontier determined by a representative peer group. In the Farell framework, a firm's efficiency is measured relative to the efficiency of all other firms in the industry, subject to the restriction that all firms are on or below the frontier. A firm is regarded as technically efficient if it is operating on the best-practice production frontier in the industry. The degree of technical efficiency is given by the ratio of the minimal input required to the actual input use, given the input mix used by the firm. It tells the utility manager the amount by which all inputs could be reduced without a reduction in output. Technical efficiency takes the values between zero and one ($0 \leq TE_i \leq 1$). Technically inefficient production units have a TE_i value less than one, while the efficient ones have a TE_i value of 1.

As seen in the foregoing discussion, empirical estimates of efficiency measures involve two steps: (i) estimation of the frontier and (ii) calculation of the individual water utility deviations from the frontier. Currently, there are two approaches used in estimating frontiers (see for instance, Coelli et alt 1998 or Coelli et alt. 2001). These are the *parametric* approach, which relies on econometric methods, and the *non-parametric* approach, which involves *linear programming* techniques. The *stochastic* and *parametric* frontiers are considered in the present study, and computed through panel estimation techniques.

3.2 Stochastic Frontier Models and Unbalanced Panel Data

Our empirical work focuses on the estimation of a stochastic frontiers for a panel of data. This implies, among other problems, having to make assumptions about the distribution of the technical efficiency, also accepting that the distribution of the technical efficiency of a firm and the regressors (inputs) are independent. This assumption is very restrictive because it is reasonable to think that if the firm knows its inefficiency level, the selected quantities of the inputs can be affected. The statistical analysis of econometric models with panel data allows applications to the estimations of frontier models to be developed and, with them, one can partially solve the estimation problems[2].

Schmidt and Sickles (1984) established the basic idea and Cornwell extended it in 1990 (Cornwell et al., 1990). The model suggested was as follows: if we have a data panel composed by T temporal observations for N productive units, we can represent the technology with the following production function (we assume a linear technology for simplicity):

$$y_{it} = \alpha + \sum_{k=1}^{K} x_{kit}\beta_k + \varepsilon_{it}, \quad i = 1,\ldots,N; \; t = 1,\ldots,T; \; k = 1,\ldots,K \qquad (1)$$

where

$$\varepsilon_{it} = \upsilon_{it} - u_i \qquad (2)$$

where y denotes the output, x_k represents the kth inputs and β_k stands for the output elasticity with respect to the kth input. Finally, ε is a composed error terms; υ_{it} is a disturbance term with the usual characteristics [iid, $N(0,\sigma^2_\upsilon)$] that captures the random factors that can explain the divergence between the observed and the potential output enumerated above and u_i captures the time-invaring latent individual effects. Then, the u_i's are positive and iid with mean μ and variance σ^2_u and they are independent of υ_{it}. That is, [$u_i \approx D(\mu, \sigma^2_u)$].

Therefore the parameter μ represents the latent average inefficiency level of technology. We can also estimate (or not) a particular distribution for u_i, and we can assume (or not) that inefficiency is correlated with the inputs. The technical efficiency measurement of an ith firm will be obtained from

$$ET = e^{-ui} \qquad (3)$$

This model is a simple generalization of the stochastic frontier models corresponding to the usual literature of panel data models with individual effects. The only difference with the standard panel data models is that in Equation 1 the individual effects (u_i) are one-sided.

[2] Simar's article (1992) constitutes a good survey of the frontier methodology with panel data, with an application of the different methods and estimators proposed.

Following Schmidt and Sickles (1984) the model can be managed in the following way. Since we know that $E(u_i) = \mu > 0$, we can define:

$$\alpha^* = \alpha - \mu \tag{4}$$

$$u_i^* = u_i - \mu \tag{5}$$

and consequently u^*_i is independent and identically distributed with $E(u^*_i) = 0$. Therefore, the model (1) can be expressed as follows:

$$y_{it} = \alpha^* + \sum_{k=1}^{K} x_{kit}\beta_k + \upsilon_{it} - u_i^* \tag{6}$$

Now, the two errors have mean zero and therefore we can directly apply all the results of panel data models. As a result, we can use the different estimators proposed in the econometric literature of panel data, the fixed effects model or the random effects models. The choice between these two models, as is well known, will depend on the possible correlation between the individual effects and the observable explanatory variables, in this case, the inputs (x_k).

If this correlation exists, the parameters of the model Equation 5 can be estimated with the within groups (WG) estimators. The individual effects can be defined as $\alpha_i = \alpha^* - u_i = \alpha - u_i$ and their estimation will be obtained from the within estimators of the parameters of the model $\left(\hat{\beta}_k^{WG}\right)$.

From this estimation of the N independent terms $\left(\hat{\alpha}_1, \hat{\alpha}_2, ..., \hat{\alpha}_N\right)$ an estimation of the independent term and the level of (in) efficiency (u_i) can be obtained from a simple procedure:

$$\hat{\alpha} = \max(\hat{\alpha}_i) \tag{7}$$

$$\hat{u}_i = \hat{\alpha} - \hat{\alpha}_i \tag{8}$$

$$ET_i = e^{-\hat{u}_i} \tag{8}$$

This transformation is necessary in order to obtain positive values for all the u_i. It is a translation of the frontier suggested by Greene (1980). With this operation the technical efficiency index of the most efficient firm will be equal to one[3].

The second way to estimate Equation 5 proposed in the panel data literature is the random effects models Generalized Least Squares (GLS) estimator. These models must be used when unobservable individual effects are not correlated with the regressors because they are more efficient than the within estimators. Thus, the problem of this estimator lies in the necessity to assume that the individual effects (efficiency level of the firms) and the explanatory variables (inputs) are not correlated. That is, in this case, one does not admit the possibility that if the firm know its inefficiency level it will be conditioned to choose the quantities of inputs in its productive process.

From this GLS estimation of the parameters $\left(\hat{\beta}_k^{GLS}\right)$, one can recover the individual effects from the residuals, and with them one makes the same operation as in the fixed effects models to recover the technical efficiency index. Note that this procedure also gives us an estimation of σ^2_u.

4. EMPIRICAL SPECIFICATION

We specify a Cobb-Douglas production frontier. Output is measured by the yearly water production, and labor, capital and materiel quantities are the main inputs considered. Other variables of interest are: the energy cost and the number of connections. Taking logarithms from this Cobb-Douglas production function we have:

$$y_{it} = \alpha + \beta_K k_{it} + \beta_M m_{it} + \beta_L h_{it} + \beta_{EC} ec_{it} + \beta_{PS} ps_{it} + \alpha_{CU} cu_{it} + \gamma t + \varepsilon_{it} \qquad (10)$$

$$\varepsilon_{it} = \upsilon_{it} - u_{it} \qquad (11)$$

where y, k, m and h represent, respectively, the logarithms of the real output, the real capital stock, the materials in constant prices, the hours of work, the energy costs in constant prices and the number of connections; the coefficients β_K, β_M, β_L , β_{EC} and β_{NC} are the output

[3] We can find a problem of inconsistency as theory tells us that α_i estimations will be consistent if $T \to \infty$.

elasticities of inputs, and the sum of them gives us the elasticity of scale, which indicates the returns to scale. There is also the variable cu which is a measurement of capacity utilization; the role of this measure is to introduce links with input flows, and t is a variable added here to measure the Hicks-neutral technical change, that is common among firms in the same sector. The composed error term combines ε_{it}, which is assumed to be normally distributed and uncorrelated with the u_i and with the explanatory variables, with u_i, which captures the level of inefficiency of the water firm and so it will be greater or equal to zero.

The main justifications for the selection of this specification of a water production function for Africa are the following. First, in most African countries, the production cost structure is not know or the degree of uncertainty surrounding cost structures is relatively high, therefore it is better to estimate a production function rather than a cost function. Second, in most classical papers, capital and length of network are two key variables; while in the present case, those two variables are highly correlated (multi-colinearity issue). That means that one of these two variables should be used but not both of them. Third, in the specific context of African countries, the number of connections is a very important variable since the average size family is between 7 and 9 for some African countries and even more for others (free rider issue). Finally, the variable t should capture technological impact within the water industry in Africa.

As for the mains issues relating to the estimation procedure, they can be summarized as follows. Since we have an unbalanced panel of data and water firms are of diverse size (small, medium and large), it is unlikely that the model would pass a test of homoskedastic variances. Even logarithmic specifications postulating percentage variation across cross-sectional units are likely to be heteroskedastic, because observations for lower output firms are likely to evoke larger variances [e.g., see Kumbhakar and Bhattacharyya, 1996; Baltagi and Griffin, 1988]. Moreover, the estimation of a seemingly unrelated regression model with an unbalanced panel of data set gives rise to some estimation problems [e.g., see Baltagi, 1995 and Schmidt, 1977]. For different time periods, there are different number of units (i.e., firms drop out without replacement) which change the ordering of observations. Since it dictates the structure of the variance-covariance matrix [e.g., see Baltagi, 1985], the ordering is important.

Furthermore, as $N \rightarrow \infty$ we can consistently separate the intercept α from the one-sided individual effects.

Therefore, the process of estimation proposed is the following: First, we estimate the model Equation (10) with the Within Group (WG) estimator. This estimator is consistent when the individual effects (inefficiency) are correlated with the other variables in the model (productive factors) or when this correlation does not exist. Second, one obtains Generalized Least Squares (GLS) estimators. This estimator is more efficient than the WG, when none of the variables are correlated with the individual effects. If this correlation exists, WG estimation is required. To determine the most suitable model, a Hausman test to decide whether to use one estimator or the other is provided.

Another problem presented in the estimation of a production function is the possible endogeneity of the explanatory variables. In general, one can expect that labor input may be simultaneously determined with output. In order to take this problem into account, the instrumental variable (IV) estimation of model Equation 10 is also presented. The instruments used in these estimations are based on energy costs (contemporaneous or one-period lagged). To check the endogeneity of labor a Hausman simultaneity test is also provided.

Additional problems exist with this last estimation procedure: for example, there is a question as to whether one should use differences or levels as instruments. Arellano (1989) gives evidence that the latter is preferable. More recently, Ahn and Schmidt (1993) observed that the IV estimator neglects quite a lot of information and is therefore inefficient. They thus proposed a more general estimator based on GMM.

5. RESULTS

The results summarized here provide an answer to each one of the policy concerns identified earlier. In addition, they allow to point to more structural issues in the sector thanks to an analysis of the shifts of the frontier during the period of analysis.

5.1 A synthetic indicator of Africa's water utilities

Table 2 displays the estimated coefficients and statistical significance tests. In addition, we also present the Hausman test result to discriminate among methods of estimation, based on econometric contrasts. We start by estimating Equation (10) based on the WG estimator. Then we apply the statistical tests on the residuals: tests for autocorrelation, tests for heteroskedasticity, tests for multicollinearity, tests for normality etc. The diagnostics clearly indicate, as expected, a serious problem of heteroskedasticity. Second, as suggested by Greene (1980), we apply a transformation to the original data and re-estimate the model in order to get the GLS estimates. The results are very satisfactory. Out of six explanatory variables, four are significant. Capital input is not significant across all the estimations and has an unexpected sign. The explanation may be that the selected functional form is not adequate; and/or that there is a great heterogeneity among firms within the African water industry. It may also reflect to trend to focus more on small scale operations discussed earlier.

Results confirm the non-endogeneity of labor as seen from the Hausman simultaneity test. The estimation with the GMM has given similar results. Note also that the GLS is the favorite due to the absence of correlation between the individual effects and the explanatory variables confirmed by the Hausman test.

Table 2: Estimation Results and Diagnostic Tests

Dependent variable: Total water production				
Regressor	Specification (standard deviation)*			
	WG	GLS	GMM	IV
Constant	1.712[a] (0.133)	0.001[a] (0.125)	1.735[a] (0.145)	1.775[a] (0.135)
Capital	0.0017 (0.00037)	0.00016 (0.00034)	0.00015 (0.00033)	0.00015 (0.00034)
Materials	0.00092[a] (0.00031)	0.00013[a] (0.00030)	0.00014[a] (0.0004)	0.00015[a] (0.0005)
Labor	0.0016[a] (0.00046)	0.0017[a] (0.00044)	0.0016[a] (0.00045)	0.0018[a] (0.00047)
Energy Costs	-0.00006 (0.00018)	-0.00007 (0.00017)	-0.00006 (0.00019)	-0.0008 (0.0002)
Technology	-0.00037 (0.00039)	-0.00037 (0.0004)	-0.00037 (0.0005)	-0.00039 (0.0006)
Diagnostics				
Degree of Freedom	31	31	31	31
$\overline{R}^2$	0.38	0.39	0.27	0.28
S.e.e	2.30%	2.11%	2.40%	2.43%
Error auto-correlation***	1.81	1.86	1.83	1.79
Durbin 'h'				
LM (1)	$F_{6,31} = 0.63$	0.54	0.72	0.81
ARCH (1)**	F(1,68 = 0.05	0.02	0.04	0.05
Normality	$Z(2) = 0.76$	0.75	0.77	0.78
Reset (1)	$F_{(1,53)} = 0.22$	0.18	0.25	0.27
Hausman Test				
$\chi 2(5)$	6.86	1.21	2.23	NO

Notes :* 't' statistics are derived using heteroscedastic - consistent estimates of standard-errors.

** the errors auto-correlation tests and the ARCH tests are all adjusted for gaps.

For the sample analyzed and the period covered, the average performance is only 54% which is not great and the standard deviation is .19. The top performers score high at 85 and 83% which is close to three times the score of the bottom performers who score between 30 and 35%.

5.2 Is Small Costly?

Table 3 reports the elasticity of scale and the rate of technical progress within the water sector. These two variables are important to the extent that they provide some insights on the trade-offs between a CDD approach to water management and a utilities based approach. The scale indicator suggests that constant return to scale prevails in the WSSUs in African water industry. This implies that there is no major reason to worry for the costs consequences of the leakage of clients from utilities towards smaller scale operations.

The second indicator is the rate of technical progress reveal. It turns out that the impact of technology is very limited in the context of WSSUs in African water industry during the period under analysis. Suggesting once more that the cost of the diversification of water supply providers is not costly at least in terms of not benefiting from technological improvement often expected from large utilities. This latter result should be taken with caution due to the sample size.

Table 3: RELEVANT PARAMETERS

Country	Water Utility	*Elasticity of Scale*				Rate Technical Progress (%)			
		WG	GLS	GMN	IV	*WG*	GLS	GMN	IV
Benin	SBEE	0.55	0.51	0.55	0.48	0.3[b]	0.1[b]	0.4[b]	0.3[b]
Burkina Faso	ONEA	0.43	0.44	0.47	0.40	0.5[b]	0.4[b]	0.3[b]	0.8[b]
Côte d'Ivoire	SODECI	0.44	0.41	0.40	0.39	0.2[b]	0.3[b]	0.3[b]	0.9[b]
Ethiopia	AA WSA	0.33	0.30	0.30	0.31	0.4[b]	0.8[b]	0.8[b]	0.7[b]
Ghana	GWSC	0.68	0.70	0.70	0.71	1.7	1.8	1.8	1.9
Mauritius	CWA	0.53	0.51	0.51	0.52	0.3[b]	0.4[b]	0.4[b]	0.3[b]
Morocco	ONEP	0.93[a]	0.98[a]	0.99[a]	0.98[a]	2.1	2.0	1.8	1.8
Morocco	RED	0.94[a]	0.91[a]	0.92[a]	0.96[a]	1.8	2.0	1.9	1.9
Namibia	WM	0.55	0.48	0.46	0.44	0.4[b]	0.3[b]	0.2[b]	0.3[b]
Niger	SNE	0.34	0.33	0.31	0.35	0.5[b]	0.7[b]	0.7[b]	0.7[b]

Nigeria	KdSWB	0.61	0.60	0.64	0.71	0.6[b]	0.7[b]	0.9[b]	0.9[b]
Nigeria	KtSWB	0.47	0.44	0.45	0.48	0.4[b]	0.4[b]	0.4[b]	0.5[b]
Nigeria	BOSWB	0.48	0.47	0.48	0.41	0.5[b]	0.5[b]	0.8[b]	0.8[b]
Nigeria	EdSWB	0.39	0.39	0.33	0.35	0.8[b]	0.9[b]	0.9[b]	0.9[b]
Senegal	SDE	0.41	0.40	0.41	0.41	0.7[b]	0.6[b]	0.5[b]	0.4[b]
South Africa	UMGENI	0.97[a]	0.98[a]	1.04[a]	1.08[a]	3.1	3.0	3.1	3.3
South Africa	RAND-W	0.96[a]	0.97[a]	1.03[a]	1.09[a]	2.4	2.3	2.3	2.5
Togo	RNET	0.31	0.30	0.30	0.33	1.1	1.1	1.5	1.5
Tunisia	SONEDE	0.88[a]	0.86[a]	0.86[a]	1.01[a]	1.7	1.8	1.8	1.9
Uganda	NWSC	0.76	0.77	0.78	0.79	1.2	1.2	1.0	1.3
Zambia	LMSC	1.01[a]	1.05[a]	1.05[a]	1.06[a]	1.5	1.4	1.3	1.2

5.3 Do Institutional factors such a ownership and governance matter?

Recent studies have shown that institutional factors at the discretion of the management as well as environmental factors beyond the control of managers or regulators affect water efficiency (e.g, see Ferrier and Valdmanis 1996, Valdamnis 1992, Ozcan and Luke 1993, Rosko et al. 1995). Some of the factors that influence the efficiency of water utilities cited in the literature are: corruption (various indices), governance (various indices) etc. This can be tested from the results obtained here.

The efficiency scores of water utilities are examined using a *censored tobit model* to identify factors influencing inefficiency. The environmental variables are excluded as their numbers are not sufficiently large to undertake a multivariate analysis.

In the tobit model, for computational convenience it is preferred to assume a censoring point at zero (e.g, see Greene, 1993).

Formally, the tobit model is defined as follows:

$$\begin{aligned} y_i^* &= \beta_i x_i + \zeta_i \\ y_i &= y_i^* \; if \; y_i^* > 0 \\ y_i &= 0 \; if \; y_i^* < 0 \end{aligned} \qquad (12)$$

where $\zeta_i \sim N(0, \sigma^2)$, and

y_i is the observed inefficiency score;

β_i is a k x 1 vector of unknown parameters;

x_i is a k x 1 vector of explanatory variables.

The empirical model, therefore, takes the following form:

$$INEFF = \beta_0 + \beta_1 CORRINDEX + \beta_2 GOVERNINDEX + \beta_3 DUM + \varsigma \quad (13)$$

where:

INEFF is the inefficiency score;

CORRINDEX is the corruption index;

GOVERNINDEX is the governance index;

DUM is a dummy variable: = 1 if the water utility is private; = 0 otherwise.

Statistical analyses are performed using STATA 5 statistical software (Statacorp 1997).

Results are displayed in Table 7. An important feature of the results is that institutional variables are statistically significant at the five percent level; their signs are also as expected. An interpretation of these results corroborate the fact that corruption is negatively linked to efficiency while governance is positively linked. As a consequence, water utilities should also focus on institutional variables when trying to improve their efficiency scores.

Table 5: Inefficiency and Institutional Variables

Independent variable	Coefficient	Standard deviation
Constant	1.989**	0.508
Corruption	0.0344***	0.048
Governance	0.041**	0.0247
Dummy (Privately operated=1)	-0.028**	0.015
LR tes	35.28***	
Mc Fadden's R^2	0.348	

Notes: Numbers in parentheses are standard errors. Single, double , and triple asteriks (*) denote significance at the 10%, 5% and 1%, respectively.

A final interesting result is the effect of ownership on the efficiency of the firm.. In the present context, the dummy variable which captures the effect of privatization is statistically significant at the five percent level. In terms of policy implications, this suggests that privatization has had an impact on water utilities in the African context. This is in contrast to the results found by Estache and Rossi (2001) for Asia where no significant difference was found.

6. Conclusions

The results of this study provide preliminary empirical evidence on the performance of water utilities in many African countries. The findings suggest that many of the water utilities operate technical efficiency levels well below a best-practice frontier that is determined by the relatively efficient ones from the group. Only about 12.9 per cent of the water utilities operate efficiently as compared to their peers.[4] This finding supports the commonly held view that Africa's water sector operate at unacceptable levels of technical inefficiency but may surprise some by the extent of the problem.

The policy implications can be summarized as follows. The improvement in the efficiency of the sector should go a long way in financing the need to improve access and/or quality of water production and distribution. Continuing the public or private financing of the sector without significant efficiency improvement is a major waste of scarce resources in the region. Efficiency savings exceeds revenue from user fees which implies that average tariff levels continue to be too high as compared to what they would be if firms were operated efficiently. The poverty alleviations implications are obvious. Water should become more accessible and more affordable with major improvements in the operation of the sector and private operators have so far been able to work in that direction, even if they did not operate the best performing companies during the period under study.

The main challenges are however not in the water sector. Governance issues and the weakness of institutions have been and continue to contribute to explain a large share in the excess of costs. These problems are just as important as the ownership debate and need to be addressed as well.

REFERENCES

[1] Ahn S, and Schmidt PJ (1995) Efficient Estimation of Models for Dynamic Panel Data. Journal of Econometrics, 68: 5-28.

[2] Aigner DJ, Lovell CAK, and Schmidt PJ (1977) Formulation and Estimation of Stochastic Frontier Production Function. Journal of Econometrics, 6: 21-37.

---

[4] Bear in mind that stochastic and parametric methods do not give a measure of absolute efficiency and that the efficiency scores only reflect the performance and production technology of the group. It is possible that the addition of more water utilities in the sample or increasing the panel is likely to increase the number of inefficient water utilities.

[3] Arellano, M (1989) A Note on the Anderson-Hsiao Estimator for Panel Data. Economics Letters, 31: 337-341.

[4] Ashton, JK (2000) Cost Efficiency in the UK's Water and Sewerage Industry', Applied Economics Letters, 7: 455-458.

[5] Baltagi BH (1985) Pooling Cross-Sections With Unequal Time-Series Lengths. Economics Letters 18, 133-146.

[6] Baltagi BH (1995) Econometric Analysis of Panel Data. New-York: John Wiley and Sons, 1995.

[7] Baltagi BH, and Griffith JM (1988) A Generalized Error Component Model with Heteroskedasticic Disturbances. International Economic Review 29, 745-753.

[8] Battese, GE, and Coelli TJ (1988). Prediction of farm-level technical efficiencies with a generalized frontier production and panel data. Journal of econometrics 38, 387-399.

[9] Battese, GE, and Coelli, TJ (1992). Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India. Journal of productivity analysis 3, 153-169.

[10] Bauer PW, Berger AN, Ferrier GO, and Humphrey DB (1998) Consistency Conditions for Regulatory Analysis of Financial Institutions: A Comparison of Frontier Efficiency Methods. Journal of Economic and Business, 50: 85-114.

[11] Bhattacharyya A, Harris TR, Narayanan R, and Raffiee K (1995) Technical Efficiency of Rural Water Utilities. Journal of Agricultural and Resource Economics 20, 373-391.

[12] Bishop M and Thompson D (1992) Regulatory Reform and Productivity Growth in the UK's Public Utilities', Applied Economics, 24: 1181-1190.

[13] Bravo-Ureta BE, and Rieger L (1991) Dairy Farm Efficiency Measurement using Stochastic Frontiers and Neo-Classical Duality. American Journal of Agricultural Economics 10: 421-428.

[14] Chamberlain, G (1980) Analysis of covariance with qualitative data. Review of Economic Studies 47, 225-238.

[15] Coelli, TJ and S. Perelman 1998. A comparison of parametric and non parametric distance functions: with application to European railways. European Journal of

Operations Research 117: 326-339.

[16] Cornwell C, Schmidt P, and Sickles RC (1990) Production Frontiers with Cross -Sectional and Time Series Variation in Efficiency Levels. Journal of Econometrics, 46: 185-200.

[17] Djerrari, FM, and Janssens, JG (1998) Overview paper on Institutional Options For Urban Water and Sanitation Services in Africa', WUP, Abidjan.

[19] Eglal R, Rathgeber E and Brooks DB (1996) Water Management in Africa and the Middle East. Edited by Eglal R, Rathgeber E and Brooks DB

[17] Farell MJ (1957) The Measurement of Production Efficiency. Journal of Royal Statistical Society, Series A, 120: 253-281.

[18] Featherston AM, Langemeier MR and Ismet M (1997) A Non-Parametric Analysis of Efficiency for a Sample of Kansas Beef Cow Farms. Journal of Agricultural and Applied Economics, 29: 175-184.

[19] Ferrier GP, and Lovell CAK (1990) Measuring Cost Efficiency in Banking: Econometric and Linear Programming Evidence. Journal of Econometrics, 46: 229-245.

[20] Forsund FR, Lovell CAK, and Schmidt P (1980) A survey of Frontier Functions and of their Relationship to Efficiency Measurement. Journal of Econometrics, 13: 5-25.

[21] Greene WH, (1980) Maximum Likelihood Estimation of Econometric Frontier Functions. Journal of Econometrics, 13: 27-56.

[22] Greene WH, (1997) Frontier Production Functions. In M. Pesaran and P. Schmidt, Handbook of Applied Econometrics: Volume II: Microeconomics. London: Blackwell Publishers.

[23] Hausman, JA and Taylor WE (1981) Panel Data and Unobservable Individual Effects. Econometrica 30, 34-53.

[24] Hunt LC, and Lynk EL (1995) Privatisation and Efficiency in the UK Water Industry: An Empirical Analysis. Oxford Bulletin of Economics and Statistics 57, 371-388.

[25] Jondrow J, Lovell CAK, Materov IS and Schmidt P (1982) On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model.

Journal of Econometrics, 19: 233-238.

[26] Kumbhakar, SC, and Bhattacharyya A (1996) Productivity Growth in Passenger-Bus Transportation: A Heteroskedastic Error Component Model with Unbalanced Panel Data. Empirical Economics, 21: 557-573.

[27] Meeusen W, and van den Broeck J (1977) Efficiency Estimation from Cobb -Douglas Production Functions with Composed Error. International Economic Review, 18: 435-444.

[28] Mundlak Y (1978) On the Pooling of Time Series and Cross Section Data. Econometrica 46, 69-85.

[29] Perelman S, and Pestieau P (1988) Technical Performance in Public Enterprises European Economic Review, 32: 432-441.

[30] Sanchez PC, and Villarroya JM (2000) Efficiency, Technical Change and Productivity in The European Rail Sector: A Stochastic Frontier Approach. International Journal of Transport Economics, 27: 55-76.

[31] Schmidt P, and Lovell CAK (1979) Estimating Technical and Allocative Inefficiency Relative to Stochastic Production and Cost Frontiers. Journal of Econometrics, 9: 343-366.

[32] Schmidt P, and Sickless R. (1984) Production Frontier and Panel Data. Journal of Business and Economics Statistics, 2: 367-374.

[33] Sengupta JK, and Monsour K (1986) Efficiency in Water Allocation under stochastic Demand. Applied Economics, 18: 37-48.

[34] Seale, J.L., Jr. (1990) Estimating Stochastic Frontier Systems With Unbalanced Panel Data: The Case of Floor Tile Manufactories in Egypt. Journal of Applied Econometrics, 8: 59-74.

[35] Shepard RW (1970) Theory of Cost and Production Functions. Princeton: Princeton University Press.

[36] Simar L, (1992) Estimating efficiencies from frontier models with panel data: a comparison of parametric, non-parametric and semi-parametric methods with Bootstrapping, Journal of productivity analysis 3, 171-203.

[37] Taylor, WE (1980) Small sample considerations in estimation from panel data. Journal of Econometrics 13, 203-223.

[38] Vickers J and Yarrow G (1988) Privatization: An Economic Analysis MIT, Press; Cambridge, MA.

[39] Water Utilities Partnership (2000) Performance Indicators of Some African Water Supply and Sanitation Utilities. Abidjan, Cote-d'Ivoire, February 2000.

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS2868	Universal(ly Bad) Service: Providing Infrastructure Services to Rural and Poor Urban Consumers	George R. G. Clarke Scott J. Wallsten	July 2002	P. Sintim-Aboagye 38526
WPS2869	Stabilizing Intergovernmental Transfers in Latin America: A Complement to National/ Subnational Fiscal Rules?	Christian Y. Gonzalez David Rosenblatt Steven B. Webb	July 2002	B. Mekuria 82756
WPS2870	Electronic Security: Risk Mitigation In Financial Transactions—Public Policy Issues	Thomas Glaessner Tom Kellermann Valerie McNevin	July 2002	E. Mekhova 85984
WPS2871	Pricing of Deposit Insurance	Luc Laeven	July 2002	R. Vo 33722
WPS2872	Regional Cooperation, and the Role of International Organizations and Regional Integration	Maurice Schiff L. Alan Winters	July 2002	P. Flewitt 32724
WPS2873	A Little Engine that Could ... Domestic Private Companies and Vietnam's Pressing Need for Wage Employment	Liesbet Steer Markus Taussig	August 2002	H. Sutrisna 88032
WPS2874	The Risks and Macroeconomic Impact of HIV/AIDS in the Middle East and North Africa: Why Waiting to Intervene Can Be Costly	David A. Robalino Carol Jenkins Karim El Maroufi	August 2002	C. Fall 30632
WPS2875	Does Liberté=Egalité? A Survey of the Empirical Links between Democracy and Inequality with Some Evidence on the Transition Economies	Mark Gradstein Branko Milanovic	August 2002	P. Sader 33902
WPS2876	Can We Discern the Effect of Globalization on Income Distribution? Evidence from Household Budget Surveys	Branko Milanovic	August 2002	P. Sader 33902
WPS2877	Patterns of Industrial Development Revisited: The Role of Finance	Raymond Fisman Inessa Love	August 2002	K. Labrie 31001
WPS2878	On the Governance of Public Pension Fund Management	Gregorio Impavido	August 2002	P. Braxton 32720
WPS2879	Externalities in Rural Development: Evidence for China	Martin Ravallion	August 2002	C. Cunanan 32301
WPS2880	The Hidden Costs of Ethnic Conflict: Decomposing Trends in Educational Outcomes of Young Kosovars	Soumya Alva Edmundo Murrugarra Pierella Paci	August 2002	T. Bebli 39690
WPS2881	Returns to Investment in Education: A Further Update	George Psacharopoulos Harry Anthony Patrinos	September 2002	N. Vergara 30432

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS2882	Politically Optimal Tariffs: An Application to Egypt	Dorsati Madani Marcelo Olarreaga	September 2002	P. Flewitt 32724
WPS2883	Assessing the Distributional Impact of Public Policy	B. Essama-Nssah	September 2002	O. Kootzemew 35075
WPS2884	Privatization and Labor Force Restructuring around the World	Alberto Chong Florencio Lopez-de-Silanes	September 2002	H. Sladovich 37698
WPS2885	Poverty, AIDS, and Children's Schooling: A Targeting Dilemma	Martha Ainsworth Deon Filmer	September 2002	H. Sladovich 37698
WPS2886	Examining the Feasibility of Livestock Insurance in Mongolia	Jerry R. Skees Ayurzana Enkh-Amgalan	September 2002	E. Laguidao 82450
WPS2886	Examining the Feasibility of Livestock Insurance in Mongolia	Jerry R. Skees Ayurzana Enkh-Amgalan	September 2002	E. Laguidao 82450
WPS2887	The Demand for Commodity Insurance by Developing Country Agricultural Producers: Theory and an Application to Cocoa in Ghana	Alexander Sarris	September 2002	M. Fernandez 33766
WPS2888	A Poverty Analysis Macroeconomic Simulator (PAMS) Linking Household Surveys with Macro-Models	Luiz A. Pereira da Silva B. Essama-Nssah Issouf Samaké	September 2002	R. Yazigi 37176
WPS2889	Environmental Performance Rating and Disclosure: China's Green-Watch Program	Hua Wang Jun Bi David Wheeler Jinnan Wang Dong Cao Genfa Lu Yuan Wang	September 2002	Y. D'Souza 31449